

SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE
OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION
FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, NOVEMBER 3, 1905.

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MSs. intended for publication and books, etc., intended
for review should be sent to the Editor of SCIENCE, GAR-
SON-ON-Hudson, N. Y.

THE ORIGIN OF SPECIES THROUGH ISOLATION.

For me, it is the chorology of organisms, that
is to say, the study of all the important phe-
nomena embraced in the geography of animals and
plants, which is the surest guide to the study of
the real phases in the process of the formation of
species. (Moritz Wagner.)

It is now nearly forty years since Moritz
Wagner (1868) first made it clear that
geographical isolation (räumliche Sonder-
ung) was a factor or condition in the for-
mation of every species, race or tribe of
animal or plant we know on the face of
the earth. This conclusion is accepted as
almost self-evident by every competent
student of species or of the geographical
distribution of species. But to those who
approach the subject of evolution from
some other side the principles set forth by
Wagner seem less clear. They have never
been confuted, scarcely even attacked, so
far as the present writer remembers, but
in the literature of evolution of the present
day they have been almost universally
ignored. Nowadays much of our discus-
sion turns on the question of whether or
not minute favorable variations would en-
able their possessors little by little to gain
on the parent stock, so that a new species
would be established side by side with the
old, or on whether a wide fluctuation or
mutation would give rise to a new species
which would hold its own in competition
with its parent. In theory, either of these
conditions might exist. In fact, both of
them are virtually unknown. In nature a
closely related distinct species is not often

quite side by side with the old. It is simply next to it, geographically or geologically speaking, and the degree of distinction almost always bears a relation to the importance or the permanence of the barrier separating the supposed new stock from the parent stock.

A flood of light may be thrown on the theoretical problem of the origin of species by the study of the probable origin of species with which we may be familiar, or of which the actual history or the actual ramifications may in some degree be traced.

In such cases, one of the first questions naturally asked is this: Where did the species come from? Migration forms a large part of the history of any species or group of forms. The fauna of any given region is made up of the various species of animals living naturally within its borders. The flora of a region is made up of the plants which grow naturally within its borders. Of all these, animals and plants, the inhabitants of most regions are apparently largely migrants from some other region. Some of them have entered the region in question before acquiring their present specific characters; others come after having done so. Which of these conditions apply to any individual case can generally be ascertained by the comparison of individuals along the supposed route of migration. Thus the Tahoe trout is clearly a migrant from the Columbia River, its separation apparently dating from the time when the former lake basin of Nevada (Lake Lahontan) found its drainage in the Columbia. We know that the present specific characters of this trout were assumed within its present range, because these traits are not found in any other trout along the supposed line of its migrations. On the other hand, we feel certain that the salmon of New England originated as a species in Europe. In extending its range from its primitive home, it has not undergone any

material change or acquired any distinctive characters, while both in Europe and in America it has more or less modified landlocked variants.

The region from which a group of animals is supposed to be derived is spoken of as its center of dispersion.

Thus the various forms of trout, originally of marine origin, seem to have diverged from the Siberian region, eastward and westward. This region is, therefore, the center of dispersion of trout. In like manner the tanagers have their center of dispersion in South America; the humming birds also. The lemurs have their center of dispersion in Madagascar, and the cat tribe in tropical Africa.

In general, although not always, the original home of any group of animals will show more varied forms than those in any other region. There may be some representatives more highly specialized, more primitive forms are likely to be preserved, more degenerate forms may be developed, and if the type is represented by fossils, these also may exhibit a larger range of forms and characters than will be found in regions occupied through later migrations.

It is evident that the nature of any fauna bears an immediate relation to the barriers, geographical or climatic, that surround it. Whenever the free movement of a species is possible, this involving the free interbreeding of its members, the characters of a species remain substantially uniform.

[Whenever free movement and interbreeding is checked, the character of the species itself is altered.] This is the meaning of Coues's pregnant phrase: 'Migration holds species true; localization lets them slip.' In other words, free interbreeding swamps the incipient lines of variation, and this in almost every case. On the other hand, a barrier of any sort brings a certain group of individuals together. These are subjected to a selection different from that

which obtains with the species at large, and under these conditions new forms are developed. This takes place rapidly when the conditions of life are greatly changed so that a new set of demands are made on the species, and those not meeting them are at once destroyed. The process is a slow one, for the most part, when the barrier in question interrupts the flow of life without materially changing its conditions. But this is practically a universal rule: A barrier which prevents the intermingling of members of a species will with time alter the relative characters of the groups of individuals thus separated. These groups of individuals are incipient species and each may become in time an entirely distinct species if the barrier is really insurmountable.

In regions broken by few barriers, migration and interbreeding being allowed, we find widely distributed species, homogeneous in their character, the members showing individual fluctuation and climatic effects, but remaining uniform in most regards, all representatives slowly changing together in the process of adaptation by natural selection. In regions broken by barriers which isolate groups of individuals we find a great number of related species, though in most cases the same region contains a smaller number of genera or families. In other words, new species will be formed conditioned on isolation, though these same barriers may shut out altogether forms of life which would invade the open district.

Thus throughout the eastern United States, unbroken by important barriers, there is but one true species of chipmunk, *Tamias striatus*, and one species of shore-lark (*Eremophila alpestris*). In California, broken by many barriers of various sorts, there are a dozen or more different kinds of chipmunks, species and subspecies. But in the eastern states the fauna at large

is much greater, because many types of birds and other animals have found entrance there, forms which are excluded from California by the barriers which surround that region.

In the great water basin of the Mississippi many families of fishes occur and very many species are diffused throughout almost the whole area, occurring in all suitable waters. Once admitted to the water basin, each one ranges widely and each tributary brook has many species. In the streams of California, small and isolated, the number of genera or families is much smaller. Each species, unless running to the sea, has a narrow range, and closely related species are not found in the same river.

The fact last mentioned has a very broad application and may be raised to the dignity of a general law of distribution.

Given any species in any region, the nearest related species is not likely to be found in the same region nor in a remote region, but in a neighboring district separated from the first by a barrier of some sort.

The nearest relative of the Tahoe trout (*Salmo henshawi*) is the cut-throat trout (*Salmo clarki*), its parent form, which is found in the Columbia and Missouri, the two rivers interlacing at their fountain heads. The nearest relatives of the cut-throat are two forms apparently descended from it, *Salmo virginalis*, of the basin of Utah, and *Salmo stomias*, of the Platte. Next to the latter is *Salmo spilurus*, of Rio Grande, and then *Salmo pleuriticus*, of the Colorado. The latter in turn may be the parent of the Twin Lakes trout, *Salmo macdonaldi*. Always the form next away from the parent stock is onward in space across the barrier.

The nearest relative to almost any Hawaiian species of fish is found in Polynesia; that to any Polynesian species is

found on the East Indies. From the East Indies we find lines diverging to the Red Sea, to the Cape of Good Hope, to Japan, to Polynesia and Hawaii, to Australia and New Zealand. We, therefore, consider the East Indies the center of dispersion or primitive home for most types of tropical fishes. At the Isthmus of Panama the nearest relative of many species of fishes is found across the isthmus, in the West Indies. Thus the red snapper of Panama, *Lutianus colorado*, finds its analogue in the red snapper of the Caribbean Sea—*Lutianus aya*. The large black snapper of Panama, *Lutianus novemfasciatus*, finds its nearest relative in the Cubera of the Caribbean, *Lutianus cyanopterus*. The same is true of perhaps 300 other species at Panama, enough to show that the resemblance across the isthmus is not a matter of accident. The divergence between these separated forms dates apparently from the time, in the late Miocene, when the seas ceased to flow together across this isthmus.

Again, in the Atlantic, the nearest relative of the Allice shad of the north of Europe (*Alosa finta*) is the Thwaite shad (*Alosa rufa*) of farther south. Another near relative is the American shad (*Alosa sapidissima*) of our Atlantic coast. This again finds its nearest ally in the Gulf shad (*Alosa alabamæ*), and this once more in the Ohio shad (*Alosa ohioensis*).

Always the species nearest alike in structure are not found together, nor yet far apart, and always a barrier lies between. Where two closely allied forms are not found to intergrade they are called distinct species. If we find actual intergradation, the occurrence of specimens intermediate in structure, the term subspecies is used for each of the recognizable groups, thus connected.

Thus of the bluebird, *Sialia*, we have in America three main forms, the one boreal,

found in northern and western mountain regions, blue above and below alike, known as *Sialia arctica*. Another form, blue above and brown below, inhabits the whole region east of the Rocky Mountains. This is *Sialia sialis*, the common bluebird of the east, 'with the sky on its back and the earth on its breast.' In the warmer parts of the mountain region, Texas to California and southward, is still another blue bird, much like the second, but darker in color and with a large patch of brown on the back as well as on the breast. This is *Sialia mexicana*. These three are considered as distinct species because there is no evidence that intergradations occur in any part of their range. One of these species, *Sialia mexicana*, has been split up into subspecies, and this is related to the fact that its range is crossed by barriers greater than those which check the movement of the others. The typical *Sialia mexicana* is found in Mexico. *Sialia mexicana bairdi* represents it in the Rocky Mountain region, and *Sialia mexicana occidentalis*, in the Pacific Coast states. A local form, *Sialia mexicana anabelæ*, is found on the mountain called San Pedro Martir, in Southern California. Along the border line between *Sialia sialis* and *Sialia mexicana*, in Arizona and Mexico, the eastern bluebird throws off shoots called *Sialia sialis azurea*.

Widely distributed across the United States and from southern Canada to Arizona, we have the yellow warbler, *Dendroica æstiva*. This bird is chiefly yellow, olive on the back with chestnut streaks on the sides, tail feathers colored like the body, and without the white spot on the outer feathers shown in most of the other types of wood warblers composing the genus *Dendroica*.

The yellow warbler throughout its range is very uniform in size and color. Its nearest relative differs in having a shade

less olive on the back and the brown streaks on the sides narrower. This form is found in the Sonoran region, and, as along the Rio Grande, it intergrades with the first; it is called a subspecies, *Dendroica æstiva sonorana*. Further south, in central Mexico, this form runs larger in size and is recorded as *Dendroica æstiva dugesi*. Northward, through to Alaska, we have an ally of the parent bird, but smaller and still more greenish. This is *Dendroica æstiva rubiginosa*.

In the West Indies the golden warblers migrate not from south to north, but from the shore to the mountains, and possibly in consequence of the less demand of flight, the wing is shorter and more rounded, while the tail is longer. As these forms do not clearly intergrade with those of the mainland, and, for the most part, not with each other, they are held to represent a number of distinct species, although doubtless derived from the parent stock of *Dendroica æstiva*. Some of these West Indian forms are relatively large, the wing more than five inches long, and the longest known of these, the type of the species for this reason, found in Jamaica, is called *Dendroica petechia*. On the island of Grand Cayman is a similar bird, a little smaller, *Dendroica auricapilla*. Of a deeper yellow than *petechia*, and equally large, is the golden warbler of the Lesser Antilles ranging from island to island, from Porto Rico to Antigua. This form, first known from St. Bartholomew, is *Dendroica petechia bartholemica*. A smaller bird, a little different in color, takes its place in the Bahamas. This is *Dendroica petechia flaviceps*.

In Cuba the golden warbler is darker and more olive, with other minor differences from the form called *bartholemica*, of which it may be the parent. This is *Dendroica petechia gundlachi*. A similar bird, but with the crown distinctly chestnut, is *Dendroica petechia aureola*, the

golden warbler of the Galapagos and Cocos Islands, off the coast of Ecuador and Peru. Scattered over other islands are smaller golden warblers with the wing less than five inches long, and with the crown tawny red, as in *aureola*. These are known collectively as *Dendroica ruficapilla*, the type being from Guadeloupe and Dominica. More heavily streaked, with the crown darker in color, is the golden warbler of Cozumel, *Dendroica ruficapilla flavivertex*, and with very similar but with darker crown is *Dendroica ruficapilla flvida*, of the island of St. Andrews. Always the nearest form lies across the barrier, and among these forms the chief barrier is the sea. With a darker chestnut crown is *Dendroica ruficapilla rufopileata*, of the island of Curaçao, and still darker bay is the crown of *Dendroica ruficapilla capitalis*, the golden warbler of the Barbadoes.

Still other golden warblers exist, with the chin and throat chestnut as well as the crown. One of these, olive green on the back, is *Dendroica rufigula*, of Martinique. The others are more yellow. One of these, with the sides heavily streaked, inhabits the isthmus region, *Dendroica erythachoides*, called a distinct species, because no intergradations have been made out. Another more faintly streaked replaces it on the Atlantic coast from Yucatan to Costa Rica, *Dendroica bryanti*, while the Pacific coast, from Sinaloa to Costa Rica, has another form, with still fainter markings, *Dendroica bryanti castaniceps*. An extreme of this form with the throat and breast tawny, but not the crown, is found in Jamaica again and is known as *Dendroica eoa*. In this case, which is one typical of most groups of small birds, the relation of the species to the barriers of geography is so plain as to admit of no doubt or question. Given the facts of individual fluctuation and of heredity, it is manifest that while natural selection may

produce and enforce adaptation to conditions of life, the traits which distinguish species bear little relation to utility. The individuals which, separated from the main flock, people an island, give their actual traits to their actual descendants, and the traits enforced by natural selection differ from island to island. If external conditions were alike in all the islands the progress of evolution would perhaps run parallel in all of them, and the only differences which would persist would be derived from differences in the parent stock. As some difference in environment exists, there is a corresponding difference in the species as a result of adaptation. If great differences in conditions exist, the change in the species may be greater, more rapidly accomplished, and the characters observed will bear a closer relation to the principle of utility.

Doubtless wide fluctuations or mutations in every species are more common than we suppose. With free access to the mass of the species, these are lost through interbreeding. Isolate them as in a garden or an enclosure or on an island, and these may be continued and intensified to form new species or races. Any horticulturist will illustrate this.

At the risk of becoming tedious we must continue these illustrations. The contention is not that species are occasionally associated with physical barriers, which determine their range, and which have been factors in their formation. It may be claimed that such conditions are virtually universal. When the geographical origin of a species can not be shown it is because the species has not been critically studied, from absence of material or from absence of interest on the part of naturalists, this showing itself often in a semi-contemptuous attitude of morphologists and physiologists towards species mongers and towards outdoor students of nature generally. In a few cases, a species ranges widely over the

earth, showing little change in varying conditions and little susceptibility to the results of isolation. In other cases, there is some possibility that saltations, or suddenly appearing characters, may give rise to a new species within the territory already occupied by the parent form. But these cases are so rare that in ornithology, mammalogy, herpetology, conchology and entomology, they are treated as negligible quantities. In the distribution of fishes the same rules hold good, but as the material for study is relatively far less extensive and less perfectly preserved than with birds and insects, we have correspondingly less certainty as to the actual traits of species and subspecies, and the actual relation of these to the intervening barriers.

The American genus *Zonotrichia* comprises the group of streaked finches known as white crowned sparrows. Most of these agree in their grayish brown coloration, streaked with darker brown, with two black stripes on the crown of the head, the wings with two white bars and tail without white feathers. The wings and tail are long, the bill small, and there is little else to separate them from the great body of streaked sparrows, amidst which the white-crowned stand as among the largest in size.

In most of the group the crown of the head is whitish between the two black stripes. In one group of these there is no yellow on the head, these being the typical white crown sparrows, *Zonotrichia leucophrys*. The common form breeds in the Rocky Mountain region and northeastward to Labrador. It has a black patch or stripe before the eye. Northwestward, from Montana to Alaska, these sparrows have the space before the eye whitish. These are *Zonotrichia leucophrys gambeli*. Southward, coastwise, from Vancouver Island to Monterey, California, the edge of the wing becomes yellow and we have *Zonotrichia leucophrys nuttalli*.

East of the Rocky Mountains, in the same region as the typical *leucophrys*, we have the white-throated sparrow, with yellow in front of the eye, and some other differences. This is *Zonotrichia albicollis*. It does not cross the mountains and no subspecies are recognized, unless indeed the species *Zonotrichia leucophrys* be one of the offshoots. Two other species, distinct so far as we know, are recognized, *Zonotrichia coronata*, the golden crowned sparrow, breeding in Alaska, and the stately Harris sparrow, *Zonotrichia querula*, of the interior plains, migrating from Missouri and Minnesota to the Saskatchewan region. In this species the top of the head is black, with stripes of either white or yellow.

Besides these differences of color, each species has some slight peculiarity of form. *Zonotrichia albicollis*, for example, having a rounded wing and *Zonotrichia coronata* a longer tarsus than the other species.

In a discussion of the origin of certain species of chickadee Joseph Grinnell¹ makes the following observations:

It is *isolation*, either by barriers or by sufficient distance to more than counterbalance inheritance from the opposite type that seems to me to be the absolutely essential condition for the differentiation of two species, at least in birds. A strong argument in support of this conviction is that we never find two 'subspecies' breeding in the same faunal area, and no two closely similar species, except as can be plainly accounted for by the invasion of one of them from a separate center of differentiation in an adjacent faunal area (example, *Parus rufescens* of the West Coast fauna, and *Parus gambeli* of the arid Sierras meet in the Siskiyou mountains). * * *

The extremest intra-competition does not ensue until after further discrimination is impossible. * * *

Two species of approximately the same food habits are not likely to remain long evenly balanced in the same region. One will crowd out the other: the one longest exposed to local conditions and hence best fitted though ever so slightly will sur-

vive to the exclusion of any less favored invader. However, should some new contingency arise, placing the native species at a disadvantage, such as the introduction of new plants, then there might be a fair chance for a neighboring species to gain a foothold, even ultimately crowding out the native form. For example, several pairs of the Santa Cruz chickadee (*Parus rufescens barlowi*) have taken up their abode in the coniferous portion of the arboretum at Stanford University, while the plain titmouse prevails in the live oaks of the surrounding valley.

* * * The greatest rate of reproduction is presumably where the species finds itself best adapted to its environment, and this is also where the death rate is least, unless an enemy rapidly multiplies so as to become a serious check. * * * In wide ranging species subcenters arise. * * * From each of these new centers of distribution, there will be a yearly radiating flow of individuals into the adjacent country so as to escape intra-competition at any one point.

Not long since the writer addressed to certain leading ornithologists of the United States a circular letter, as given below. Certain typical answers to this letter are appended, all agreeing in general with the proposition stated above.

In considering the proposition that species in general arise in connection with geographic or topographic isolation, will you kindly answer briefly the following questions?

1. Do two or more well founded subspecies ever inhabit [breed in] the same region? If so, give examples.

2. If so, how do you explain the fact?

3. Would you regard a form as a 'subspecies' if coextensive in range with the species with which it intergrades?

4. Are there cases where two species inhabiting exactly the same region are closely related, and more closely than any other species is in either one? If so, give examples.

LEONARD STEJNEGER.

Before answering the four questions contained in your letter of February 21, just received, allow me to make a few general remarks.

I suppose that by inhabit you mean propagate, since many migrating subspecies spend part of their time in the territory of the other subspecies. It may probably be necessary to further qualify the word *propagate* by adding *simultaneously*,

¹ *Auk*, July, 1904, p. 372.

since it is thinkable at least that the subspecies might have become 'isolated' in the same locality by adopting different times of propagating. Might not such cases occur among fishes? I have also a sort of suspicion that it may occur, or may have occurred earlier, in some migratory birds on both sides of the equator. Altogether, I wish to be very reserved in my answers and I would have you understand an *obligato* 'so far as I know' added to all of them. The fact is, that the records when it comes to distinguish between the propagation habitat and the general habitat of the species are so defective that no fully reliable conclusions can be drawn from them.

1 and 2. I know of no well-founded subspecies propagating simultaneously in the same locality (I would avoid the word region as not restricted enough).

As a matter of fact I can not well conceive of two subspecies propagating simultaneously in the same locality except perhaps during a short time under the following supposition as shown by an example:

Suppose the so-called *Lanius major* of Siberia and *Lanius excubitor* were only subspecifically distinct, i. e., that they had not yet developed beyond a certain degree of character stability along the original territorial line separating them somewhere in Central Asia (a supposition I do not admit, though I do not deny the possibility, the data at hand being inconclusive). Now suppose both species extended their range westward, *L. excubitor* to central Europe thence north to the Scandinavian peninsula *via* Denmark, while *L. major* pushed northwestward over Finland to northern Norway (and these suppositions I believe are correct!). Suppose further that the breeding ranges of both subspecies met and finally overlapped, say in some localities in Finmarken (and there are indications that they do, though the records are anything but satisfactory). The chances are, of course, that in these localities the two subspecies would mix, but for some time at least it is probable that a certain percentage of both might continue to breed pure alongside of each other. Though all this is mere speculation it is probably legitimate to carry the supposition a step further. Finmarken is the most extreme end of the range of both (supposed) subspecies, it is then not unnatural to conclude that in the specimens meeting there the characters might have become so fixed that the two forms would react on each other as two distinct species, though at their original dividing line they might

still remain in the imperfectly differentiated stage.

3. No, as a rule not. But if as I hinted above the isolation were one of time of spawning, for instance, concomitant with which a certain amount of structural differentiation had taken place, then I can conceive of such a state as indicated in question 3, viz., that the ranges (in space) of both subspecies might be coextensive.

4. There are a few cases where *apparently* two species inhabiting exactly the same region (these terms restricted as above), are *apparently* more closely interrelated than to any other. As an example I may quote two Japanese birds, *Cettia cantans* and *C. cantillans*, the chief and possibly the only difference being the constantly greater size of the former. Yet we are told that they occur in exactly the same localities. I used the word *apparently* above because in the first place the *exact* relationship of the two species is not ascertained, and in the second, the records of the breeding ranges of both are not as complete as might be desired. That the two forms are distinct and do not intergrade seems certain. Altogether I do not pretend to understand the case.

There are a few other similarly puzzling cases, for instance, that of *Phyllopneuste borealis* and the so-called subspecies *xanthodyas* but apart from the fact that in this case the latter is not coextensive with the former only occupying part of the territory, the records are so incomplete and defective the chances are the puzzle may be easily solved when all the facts are known.

The case of various forms for crossbills might also be cited. In their case it almost looks as if each band is kept isolated by their gipsy-like habits, though it is just possible that they may have evolved different breeding periods or different food making them dependent on the latter for the selection of their temporary breeding locality. At any rate, the isolation does not seem to be geographical or topographical.

I hope I have been able to make my standpoint clear, viz., that two geographical subspecies can not propagate in the same locality (except in rare cases illustrated by the *Lanius* example), but that there are other kinds of isolation—or possibly better: segregation, which—though more rarely—may produce subspecies—eventually species when the incomplete differentiation has become complete,—capable of living side by side in the same locality.

WILLIAM BREWSTER.

I have no knowledge based on personal experience that two well-marked subspecies of the same

species of bird ever *breed* in the same region. It is, of course, by no means unusual for two forms subspecifically isolated to occur together during migration or in their winter homes.

If I understand your fourth question rightly I should say that there are a good many known cases of species more closely related to one another than to other species occurring (in breeding) in the same region. The best examples of this that occur to me are the Allen and Least flycatchers, the blue-winged and the golden-winged warblers (these two species interbreed fairly and their hybrid offspring is *fertile*), and the Swainson's and Bicknell's thrushes. All these breed in New England and the species mentioned in pairs breed to the same covers. I think that in England excellent examples may be found among the very closely isolated warblers belonging to the family Turdidae and the family Sylviinae.

I certainly should be loath to believe that two birds which were subspecies of the same species could breed, at least in the same area.

C. HART MERRIAM.

Your letter making inquiries as to coextensive ranges of subspecies of the same species, and so on, reached me some little time ago, but owing to pressure of other matters I have not been able to reply earlier. My answer to questions 1, 2 and 3 was no, from the first. I felt a little uncertain about the fourth question, and have spent some time in running over lists of birds and mammals in order not to make a mistake. After careful consideration I must answer this question in the same way as the others, as I fail to find any two closely related species inhabiting exactly the same region.

JOSEPH GRINNELL.

In reply to your recent circular, I offer the following:

In birds several subspecies may occur in the same region in *winter*, because of their seasonal scattering. But I know of not even one case where two subspecies *breed* in precisely the same region. I have run down two alleged cases—both proved irrelevant.

My criterion for diagnosis as subspecies is—two forms connected by a continuous series of intergrades uninterruptedly covering the interlying ground. If a geographic hiatus exists (as in island races), even though intermediates may *apparently* bridge over the difference in mean characters, I call the two forms *species*. I can see no difference between species and subspecies, except an average one in *degree* of differentiation;

and that fluctuates with personal opinion (*e. g.*, note A. O. U. rulings from year to year!). I am about ready to deny the value of trinomials in nomenclature on this account. Call all distinguishable groups of individuals *species*, as Sharpe tries to do in his 'Hand-List of Birds.' I know of no case where two species inhabiting the same region are 'closely' related, or even more closely related than any other species is to either one.

I believe in *isolation* either by barriers, or by sufficient distance to more than counterbalance invading inheritance from the opposite extreme (geographically) as being one *essential* factor in the differentiation of species.

LEVERETT MILLS LOOMIS.

1, 2. I know of no instance.

3. No.

4. I do *not* recall a case among the Tubinares, particularly in the closely related species in *Oceanodroma*, *Puffinus*, *Aotrelata*; of course 'exactly the same region' in these birds would be the breeding grounds.

CHARLES H. GILBERT.

In attempting to reply to your circular letter concerning subspecies, I am limited by the fact that well marked subspecies are hardly known in ichthyology. Unless the term shall be finally applied to such local forms as the fresh-water sticklebacks, or to the minutely variant form characteristic of different tributaries of the same hydrographic basin, I see no probability of the subdivisions of fishes beyond the species. I can not answer your questions, therefore, on the basis of personal experience with subspecies, a fact which prevents my views from having any weight. I may, however, venture the following suggestions:

The answer to all your questions will depend upon the definition given the terms 'range' and 'region.' It might well be found, for example, that two subspecies of song sparrow would occupy the Santa Clara Valley, one confined to the tule swamps, the other to the dry uplands. That two subspecies should have coextensive range and live in the same habitat within the range, would seem impossible from the accepted definition of subspecies. I refer here to the older definition of subspecies, for many well known zoologists have recently adopted the view that subspecies are determined by the small amount of divergence rather than the ascertained fact of intergradation. To those who so hold, anything would be possible with subspecies which would be possible with species.

I know of no example under question 4.

WALTER KENRICK FISHER.

1. In *Melospiza cinerea pusillula* Ridgway and *M. c. santæcrucis* Grinnell we have two conspecific races inhabiting the same region but occupying different habitats.

2. *Santæcrucis* (a distinguishable but very closely related race to *cooperi* Ridgway, of the San Diegan-Los Angeles district), dwells in the valleys and on lower mountain slopes of the Santa Cruz Mt. peninsular, and as far south as southern Monterey Co., California. It is common along the fresh-water streams emptying into both sides of the south arm of San Francisco Bay. But *M. c. pusillula* breeds only on the marshes, among the Salicornia. Its range is consequently surrounded by that of *M. c. santæcrucis*. East of Palo Alto one can stand by nests of *santæcrucis* and be within shouting distance of many nests of *pusillula*. Yet the two races never, during the breeding season, encroach upon one another's domain. The *M. c. samuelis* of Baird occupies the salt marshes along the northern arms of San Francisco Bay. So far as known it does not intergrade with *M. c. pusillula*.

3. Not if coextensive in habitat throughout a large part of the range of both forms. If intergradation was proved beyond a doubt it might be shown that one race had encroached upon another over part of its range. Intergradation has been satisfactorily established in so few cases that one would be justified in calling such forms species.

4. The only case I can recall is that of *Empidonax hammondi* and *E. wrighti*, which are practically indistinguishable out of hand. They breed commonly in the high Sierra Nevada and over western North America. So far as genetic relationship is concerned there is a probability that *hammondi* may be a descendant of the eastern *minimus* stock, while *wrighti* may be nearer *E. fulvipectus* (S. Mexico).

I have written out the only cases I know of which will bear on your questions. The song sparrow case is easily explained by a difference of habitat. The word 'region' is of course susceptible to many interpretations. In California where zones are wonderfully juxtaposed in a sort of nature's crazy-quilt one has to be unusually specific as to locality. Birds labeled Santa Clara Valley, for instance, would considerably mislead one unacquainted with the region, if he happened to receive specimens of two subspecies of song sparrow.

Referring to the land snails of the island of Oahu (Hawaii), Alfred Russel Wallace quotes from Rev. J. T. Gulick the statement that the island has in its wooded portions about 175 species of land-shells represented by 700 or 800 varieties.

We frequently find a genus represented in several successive valleys by allied species, sometimes feeding on the same, sometimes on allied plants. In every case the valleys that are nearest to each other furnish the most nearly allied forms, and a full set of the varieties of each species presents a minute gradation of forms between the more divergent types found in the more widely separated localities.

Similar conditions are recorded among the land snails in Cuba and in other regions. In fact, on a smaller scale, the development of species of land and river mollusks has everywhere progressed on similar lines with that of birds and fishes. Many other illustrations of the same sort, drawn from almost all groups of animals, have been given by Dr. Moritz Wagner, whose epoch-making work has not received from writers on organic evolution the attention it deserves. Perhaps one cause of this neglect is found in Wagner's persistent opposition to the theory of natural selection and his insistence on isolation and migration as virtually the only factors in species forming. But to recognize isolation as practically a necessary condition in the subdivision of species need not necessarily eliminate or belittle any other factor. Isolation is a condition, not a force. Of itself, it can do nothing. Species change or diverge with space and with time; with space, because geographical extension divides the stock and brings new conditions to part of it; with time, because time brings always new events and changes in all environment.

One of the most remarkable cases of group evolution is that of the song birds of Hawaii, constituting the family of Drepanidæ. In this family are about forty species of birds, all much alike as to

general structure, but diverging amazingly from each other in the form of the bill, with, also, striking differences in form of body and in plumage. In almost all other families of birds the form of bill is very uniform within the group. It is correlated with the feeding habits of the bird, and these in all groups of wide range become nearly uniform within the limits of the family. With a great range of competition, each type of bird is forced to adapt itself to the special line of life for which it is best fitted. But with many diverging possibilities and no competition, except among themselves, the conditions are changed, and we find Drepanidæ in Hawaii fitted to almost every kind of life for which a song bird in the tropics may possibly become adapted.

In spite of the large differences to be noted, there can be little doubt, as Dr. Hans Gadow, Mr. H. W. Henshaw and others have shown, of the common origin of the Drepanidæ. A strong peculiar goat-like odor exhaled in life by all of them affords one piece of evidence pointing in this direction. There is, moreover, not much doubt that the whole group is descended from some stock belonging to the family of honey-creepers, Cœrebidæ, of the forest of Central America. Each of the Hawaiian islands has its species of Drepanine birds, some olive green in color, some yellow, some black, some scarlet and some variegated with black, white and golden. The females in most cases, like the young, are olive green. On each island, most of the species are confined to a small district, to a single kind of thicket or a single species of tree, each species being especially fitted to these localized surroundings. With the destruction of the forests some of these species are already rare or extinct. With high specialization of the bill they lose their power of adaptation.

In each of the several recognized genera there are numerous species, mostly thus specialized and localized, relatively few species being widely distributed throughout the islands.

Most primitive of all, least specialized and most like the honey creeper ancestry, is the olive green *Oreomystis bairdi* of the most ancient Island of Kauai. This bird has a small straight bill, not unlike that of the slender-billed sparrow. It is said to be the most energetic and ubiquitous of the group, feeding on insects on the trunks of trees. If we assume that *Oreomystis*, or some other of the genera with short and slender bills, represents the original type of Drepanidæ, we have two lines of divergence, both in directions of adaptation to peculiar methods of feeding.

Next to *Oreomystis*, on the one hand we have *Loxops* and *Himatione*, with the bill pointed, a little longer than in *Oreomystis*, and slightly curved downwards. The species, red or golden, of these two genera are distributed over the islands, each on its own mountain or in its own particular forest. *Vestiaria*, another genus, remarkable for its beautiful scarlet plumage, has the bill very much longer and strongly curved downward. *Vestiaria coccinea*, the iiwi of the islands, lives among the crimson flowers of the ohia tree (*Metrosideros*) and the giant lobelia, where it feeds chiefly on honey, which is said to drop from its bill when shot. According to Mr. S. B. Wilson, the scarlet sickle-shaped flowers of a tall climbing plant of *Strongylodon lucidus* found in these forests 'mimic in a most perfect manner both in color and shape the bill of the iiwi' so that the plant is called nukuiwi (bill of the iiwi).

The next genus, *Drepanis*, has the sickle bill still further prolonged, forming a segment of a circle, and covering nearly 50 degrees. *Drepanis pacifica*, one of the

species, has the bill forming about one fourth of the total length. The species of this genus, black and golden in color, were very limited in range, and are now nearly or quite extinct. Still another group with sickle bills, *Hemignathus*, diverges from *Vestiaria* in having the upper mandible only very long and decurved, the lower one being relatively short, straight and stiff. The numerous species are mostly golden-yellow in color. Some or all of them use the lower mandible for tapping the trees, after the fashion of woodpeckers, while with the long and flexible upper one they reach into cavities for insects or insect larvæ or suck the honey of flowers. The group contains long-billed forms like *Hemignathus procerus* of Kauai, in which the bill is more than one fourth the total length of the bird, and short-billed forms like *Hemignathus* or *Heterorhynchus olivaceus* of Hawaii. In the short-billed forms the two mandibles are most unlike; the upper very slender, much curved and about one fourth the length of the rest of the body, the lower mandible half as long and thick and stiff. These birds feed chiefly on insects in the dead limbs of the koa trees in the mountain forests.

Mr. S. B. Wilson remarks:

Nature has shown great symmetry in regard to the species of this genus (*Hemignathus*) to be found in the Sandwich Archipelago, three of the main islands having each a long-billed and a short-billed form.

This of course is most natural. Both long-billed forms (*Hemignathus*) and short-billed forms (*Heterorhynchus*) have spread from the island where they were originally developed to the other islands, each changing as it is isolated from the main body of the species and subjected to natural selection under new conditions.

With the genus *Hemignathus* and its aberrant section, *Heterorhynchus*, the

forms with slender bills reach their culmination.

Going back to the original stock, to which *Oreomystis bairdi* is perhaps the nearest living ally, we note first a divergence in another direction. In *Rhodacanthus*, the bill is stout like that of the large finch, not longer than the rest of the head, and curved downward a little at the tip. The species of this genus feed largely on the bean of the acacia and other similar trees, varying this with caterpillars and other insects. The stout bill serves to crush the seeds. In *Chloridops*, the bill is still heavier, very much like that of a grosbeak. *Chloridops kona* is, according to Mrs. Robert Perkins, a dull sluggish solitary bird and very silent, its whole existence may be summed up in the words 'to eat.' Its food consists of the fruit of the aaka (bastard sandal tree), and as they are very minute, its whole time seems to be taken up in cracking the extremely hard shells of the fruit, for which its extraordinarily powerful bill and heavy head have been developed.

The incessant cracking of the fruits, when one of these birds is feeding, the noise of which can be heard for a considerable distance, renders the bird much easier to get than it otherwise would be. Its beak is always very dirty with a brown substance adhering to it which must be derived from the sandal-nuts.

In *Psittirostra* and *Pseudonestor* the bill suggests that of a parrot rather than that of a grosbeak. The mandibles are still very heavy, but the lower one, as in *Heterorhynchus*, is short and straight, while the much longer upper one is hooked over it. *Pseudonestor* feeds on the larvæ of wood boring beetles (*Clytanus*) found in the koa trees (*Acacia falcata*), while the closely related *Psittirostra* eats only fruits, that of the ieie (*Freycinetia arborea*), and the red mulberry (*Morus sapyrifera*) being especially chosen. In all these genera

there is practically a species to each island, except that in some cases the species has not spread from the mountain or island in which we may suppose it to have been originally developed.

There are a few other song birds in the Hawaiian Islands, not related to the Drepanidæ. These are derived from the islands of Polynesia and have deviated from the original types in a degree corresponding to their isolation.

In the case of the Drepanidæ it seems natural to conclude that natural selection is responsible for the physiological adaptations characteristic of the different genera. Such changes may be relatively rapid, and for the same reason they count for little from the standpoint of phylogeny. On the other hand, the non-useful traits, the petty traits of form and coloration which distinguish a species in Oahu from its homologue in Kauai or Hawaii, are results of isolation. These results may be analyzed as in part differences in selection with different competition, different food and different conditions, and in part to hereditary difference due to the personal eccentricities in the parent stock from which the newer species was derived.

In these and in all similar cases we may confidently affirm: The adaptive characters a species may present are due to natural selection or are developed in connection with the demands of competition. The characters, non-adaptive, which chiefly distinguish species do not result from natural selection, but from some form of geographical isolation and the segregation of individuals resulting from it.

The origin of races and breeds of domestic animals is in general of precisely the same nature. In traveling over England one is struck by the fact that each county has its own breed of sheep, each of these having its type of excellence in mutton, wool, hardiness or fertility, but

the breeds distinguished by characters having no utility either to sheep or to man.

The breeds are formed primarily by isolation. The traits of the first individuals in each region are intensified by the in-breeding resulting from segregation. Natural selection preserves the hardest, the most docile and the most fertile; artificial selection those which yield the most wool, the best mutton and the like. The breed once established, artificial selection also tends to intensify and to preserve its non-adaptive characteristic marks. The more pride the breeders take in their stock, the more certain is the preservation of the breed's useless peculiarities.

Taking the common middle-wool sheep of southern England, the following key to some of the visible race traits was made while driving along the county roads.

- a. Rams and ewes with short white horns. Dorsetshire.
- aa. No horns.
- b. Face and ears black.
- c. Skin below tail black. Hampshire.
- cc. Skin below tail white. Devonshire.
- bb. Face and legs tawny: no black. Southdown.
- bbb. Face and ears white: ears erect. Cheviot.

Not one of these characters has the slightest intrinsic or physiological value. Each of them would disappear in a few generations of crossing, and in each breed the virtues of wool or of flesh exist wholly independently of these race marks.

Analogous to these race peculiarities of sheep are the minor traits among the men of different regions. Certain gradual changes in speech are due to adaptation, the fitness of the word for its purpose, analogous to natural selection. The non-adaptive matters of dialect find their origin in the exigencies of isolation, while languages in general are explainable by the combined facts of migration, isolation and the adaptation of words for the direct uses of speech.

In the animal kingdom generally we may say: whenever a barrier is to some extent traversable, the forms separated by it are liable to cross from one side to the other, thus producing intergradations, or forms more or less intermediate between the one and the other. For every subspecies, where the nature of the variation has been carefully studied, there is always a geographical basis. This basis is defined by the presence of some sort of a physical barrier. It is extremely rare to find two subspecies inhabiting or breeding in exactly the same region. When such appears to be the case, there is really some difference in habit or in habitat; the one form lives on the hills, the other in the valleys; the one feeds on one plant, the other on another; the one lives in deep water, the other along the shore. There can be no possible doubt that subspecies are nascent species, and that the accident of intergradation in the one case and not in the other implies no real difference in origins.

Of all branches of science, we may say that the one most advanced in its development, most nearly complete in its conclusions, is that of the systematic study of American birds. No other group of naturalists has made such extensive studies of individual or of group variations as the ornithologists who have dealt with American birds. And for this reason, and on account of the excellence of the preserved material with which they have to deal, the students of our birds have thoroughly understood the relation between species-making and geographical distribution, the persistence of group variation and the origin of species.

While the processes of natural selection may be always at work destroying those individuals not fitted to their surroundings, and accentuating the adaptation of the species through those which survive, and while

sometimes natural selection may work with great acceleration where conditions are widely changed, yet it is clear that the characters by which one species is actually known from the next are rarely traits of utility. Such traits bear no visible relation to the process of natural selection, using that term in a strict sense.

For example, we may compare the species of American orioles constituting the genus *Icterus*. We may omit from consideration the various subspecies, set off by the mountain chains, and the usual assemblage of insular forms, one in each of the West Indies, and confine our attention to the leading species as represented in the United States.

The orchard oriole, *Icterus spurius*, has the tail all black, the head all black, the lower parts chestnut, and the body relatively small, as shown by the average measurements of different parts. In the hooded oriole, *Icterus cucullatus*, the head is orange, the throat black, and the wings are black and white. This species, with its subspecies, ranges from Southern California over much of Mexico. Our other orioles have the tail black and orange. In the common Baltimore oriole, *Icterus galbula*, of the east, the head is all black, and the outer webs of the wing coverts are black and white. In the equally common bullock oriole, *Icterus bullocki*, of the California region, the head is partly yellow, and the greater wing coverts are mostly black. The females of all the species are plain olivaceous, the color and proportions of parts varying with the different species, while in the males of each of the many species black, white, orange and chestnut are variously and tastefully arranged. Each species again has a song of its own, and each its own way of weaving its hanging nest.

That which interests us now is that not one of these varied traits is clearly related

to any principle of utility. Adaptation is evident enough, but each species is as well fitted for its life as any other, and no transposition or change of the distinctive specific characters or any set of them would in any conceivable degree reduce this adaptation. No one can say that any one of the actual distinctive characters or any combination of them enables their possessors to survive in larger numbers than would otherwise be the case. One or two of these traits, as objects of sexual selection or as recognition marks, have a hypothetical value, but their utility in these regards is slight or uncertain. It is customary at present to look with disfavor on sexual selection as a factor in the evolution of ornamental structures, and the psychological reality of recognition marks is yet unproved, though not at all improbable.

It may be noted, in passing, that the prevalent dull yellowish and olivaceous hues of the female orioles of all species is clearly of the nature of protective coloration.

Professor Vernon L. Kellogg has shown statistically that certain specific characters among insects have no relation to the process of selection. Among honey bees the variation in venation of the wings and in the number and character of the wing hooks is just as great when the bees first come from their cells as in a series of individuals long exposed to the struggle for existence.

Among ladybird beetles of one species (*Hippodamia convergens*) 84 different easily describable 'aberrations' or variations in the number and arrangement of the black spots on the wing covers have been traced. These variations are again just as numerous in individuals exposed to the struggle for life as in those just escaped from the pupal state. In these characters there is, therefore, no rigorous

choice due to natural selection. Such specific characters, without individual utility, may be classed as indifferent, so far as natural selection is concerned, and the great mass of specific characters actually used in systematic classification are thus indifferent.

And what is true in the case of the orioles is true as a broad proposition of the related species which constitutes any one of the genera of animals or plants. All that survive are well fitted to live, each individual, and therefore each species fitted to its surroundings as the dough is to the pan, or the river to its bed, but all adaptation lying apparently within a range of the greatest variety in non-essentials. Adaptation is the work of natural selection: the division of forms into species is the result of existence under new and diverse conditions.

To the general rule that closely allied species do not live together there exist partial exceptions. It may be well to glance at some of these, for no rule is established until its exceptions are brought into harmony with the phenomena which illustrate the rule.

The most striking case of this sort known to us is that of the Pescado Blanco of the volcanic lakes of Mexico, these constituting the genus *Chirostoma* in the family of Atherinidæ.

In the large lake of Chapala in central Mexico, tributary to the Rio Lerma, one species, *Chirostoma estor*, has been known for years. It is a pale, translucent fish of elongate form, about fifteen inches in length, with very delicate flesh, and it is much appreciated as a food fish under the local name of 'Pescado Blanco de Chapala.' In a recent visit to that region, the Pescado Blanco was found to be abundant in the lake, but to the great surprise of the writer, in the same catch of the net were found

under the same general guise of size and appearance some half a dozen distinct but closely related species of *Pescado Blanco*. In each case the different species most nearly related seemed to be found together, an exception to the rule otherwise almost universal among animals and plants. Later explorations of Dr. Seth E. Meek in this and other lakes confirmed and magnified this anomaly. The genus *Chirostoma* is confined to the lakes of the tablelands of Mexico. It includes three groups or subgenera: *Chirostoma* proper, green in color and with firm, smooth scales; *Lethostole*, with smaller scales, rough edged, the body white or translucent, and *Eslopsarum*, of smaller species, also white, but with still larger scales, larger than in *Chirostoma* or *Lethostole*. The species were found to be grouped as follows:

Lake Chapala.	{	(<i>Lethostole</i>) <i>estor</i> .
		(<i>L</i>) <i>ocotlanæ</i> .
		(<i>L</i>) <i>lermæ</i> .
		(<i>L</i>) <i>sphyræna</i> .
		(<i>L</i>) <i>lucius</i> .
		(<i>L</i>) <i>promelas</i> .
		(<i>L</i>) <i>grandocule</i> .
		(<i>L</i>) <i>chapalæ</i> .
		(<i>Eslopsarum</i>) <i>labarcæ</i> .
Lake Patzcuaro.	{	(<i>E</i>) <i>bartoni</i> .
		(<i>L</i>) <i>estor</i> .
		(<i>L</i>) <i>grandocule</i> .
		(<i>Chirostoma</i>) <i>humboldtianum</i> .
		(<i>E</i>) <i>patzcuaro</i> .
Lake Zirahuén.	{	(<i>E</i>) <i>attenuatum</i> .
		(<i>L</i>) <i>estor</i> .
Lake Chalco (City of Mexico).	{	(<i>E</i>) <i>ziráhuén</i> .
		(<i>C</i>) <i>humboldtianum</i> .
Aguas Calientes.	{	(<i>E</i>) <i>jordani</i> .
		(<i>E</i>) <i>arge</i> .

No data exist for the explanation of this peculiar case of distribution. It is possible that *C. humboldtianum* of the lakes of Mexico represents the ancestral type, that the

groups *Eslopsarum* and *Lethostole* have diverged from it, and that the numerous species of the last-named type in the large lakes, Chapala and Patzcuaro, have been formed by mutations in the sense of the use of the word by de Vries. But it is possible that these species have been formed by isolation, and that species thus formed have invaded the territory of other species. The shifting of the shores of these volcanic lakes and of the hydrographic basins to which they belong is among the possible causes to be considered.

Another curious case of the occurrence in one locality of similar species is found in the genus *Eviota* of the family of Gobiidae or gobies.

Eviota contains very minute fishes of the coral reefs, translucent green in color, plain or blotched with orange and marked with black spots. One species one and a half inches long (*Eviota abax*) is found in Japan, and one an inch long (*Eviota personata*) in the West Indies. The other species are all less than an inch in length, some of them but half an inch, perhaps the smallest of all vertebrate animals. One of these, *Eviota epiphanes*, is found in crevices in the coral reefs of Hawaii. Another, *Eviota miniata*, is recorded from Guam. All the remaining species, including those most closely related, are known only from the crevices of coral heads in Samoa. Most of the known specimens, hundreds in all, were obtained by the writer and his associates in Apia and Pago Pago. Our native assistants would dive for these coral masses, and on cracking them, the little fishes would be found in their channels and interstices. In Samoa the following species occur: *Eviota zonura*, *E. smaragdus*, *E. prasites*, *E. afelei*, *E. sebreei*, *E. pruinosa*, *E. herrei*, *E. distigma*. It would seem as if these species could not have had a geographic origin in the ordinary sense, for they are all grouped

together in the same neighborhood. It is, however, possible that the isolation of a part of the reef or even of that of a single coral head might in long periods serve the same purpose.

Enneapterygius is a genus of blennies in size and distribution closely parallel with *Eviota*. It contains species of moderate size found in the Gulf of California, in New Zealand, the Red Sea and Japan. In these same coral heads, species of this genus also occur, all of them extremely minute, much smaller than their relatives in other waters, and scarcely larger than the species of *Eviota*, among which they live. These minute fishes are mostly red in color, sometimes partly black. Again one species (*Enneapterygius atriceps*) is found in the Hawaiian reefs, and again six species (*E. minutus*, *E. hemimelas*, *E. hudsoni*, *E. tusitala*, *E. cerasinus* and *E. tutuilae*) live together in the coral heads of Samoa.

The more usual distribution of a group of closely related fishes may be shown by the group of silver-fin minnows, the section *Erogala*, in the genus *Notropis* among the fishes.

All these are small minnows, with large scales, and with the dorsal fin marked by a large black blotch on its last rays above. This fin in the males is tipped with a broad stripe of silvery or milk-white pigment, and sometimes also shaded with bright red, orange or blue, very conspicuous in the breeding season.

The simplest, most primitive and most widely distributed form is *Notropis whipplii* of the Mississippi Valley. Near to this in the Upper Tennessee is *Notropis galacturus*. In the Ozark range is *Notropis camurus*. Farther south a black spot appears at the base of the tail. This marks *Notropis notatus* in the Rio Colorado of Texas, *Notropis venustus* in the Rio

Sabinal, *Notropis cercostigma* in Pearl River, and *Notropis stigmaturus* in the Alabama. On the eastern part of its range, the nearest relative of *Notropis whipplii* is *Notropis analostanus* of the Potomac. Near to this is *Notropis niveus* of the North Carolina rivers and *Notropis chloristius* of the Santee. Other variants from these are *Notropis eurystomus* of the Chattahoochee, *Notropis xanurus* of the Allamaha, *Notropis caruleus*, *callistius* and *trichroistius* of the Alabama and Black Warrior, the last two with scarlet on the dorsal. Finally come the most specialized extremes, *Notropis pyrrhomelas* of the Santee and *Notropis hypselopterus* of the Mobile. Each southern river has one or more species of this type, and the streams of Georgia have been invaded from the north and from the west, the two types meeting in the basin of the Alabama.

In the little group of minnows called *Hydrophlox*, another section of the genus, *Notropis rubricroceus*, and its allied species, scarlet, black and golden, are distributed in precisely the same fashion, and about the same number of species are developed. Those found in the Mississippi River have the widest range of distribution and the least specialization in their traits. Those in the clear waters of the southern slope of the Blue Ridge are most intensely colored, most specialized in the traits, and show the narrowest range in distribution.

If fishes were as easily preserved, measured and examined as birds, and if they were studied by as many keen eyes, we might find perhaps that each of these species is again broken up into races or subspecies, their traits determined in some degree by their individual parentage, in larger part by the local selection they have undergone in their diverse waters and surroundings. This is certainly probable in

the case of fresh-water fishes, but with marine fishes there is greater freedom of migration, the species are perhaps largely of more ancient origin and intergrading forms are much more rarely recognized.

The degree of fulness and accuracy in the recognition of subspecies marks the degree of progress in any branch of systematic or of faunal zoology and botany. It is the tyro who, as Linnaeus² suggests, sees the problems of geographical distribution in the large. It is the master who follows step by step the footprints of the Creator in the molding and distribution of life

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SCIENTIFIC BOOKS.

The Waterlilies: A Monograph of the Genus Nymphaea. By HENRY S. CONARD, Senior Harrison Fellow in Botany, University of Pennsylvania. Published by the Carnegie Institution of Washington. 1905. Pp. xiii + 279. 4to, 30 plates and 82 figures in the text.

This thick volume, which is listed as 'Publication No. 4' of the Carnegie Institution of Washington, appeared several months ago, and attracted immediate attention on account of its excellence of paper, type, presswork and plates. In the style of its publications the institution is setting a high standard which can not but favorably affect scientific publication throughout the country. The plates are from drawings (some colored) and photographs, which have been very faithfully reproduced. The text-figures, while largely outlines, are also well done, adding greatly to the value of the work.

Turning now to the text, we find a chapter given to a historical sketch, followed by another devoted to structure, still another to development, one to physiology. The central chapter devoted to taxonomy is the longest and most important, and this is followed by brief discussions of distribution, hybrids and

garden varieties, culture and uses and an extended bibliography. From the preface we learn that 'nothing like a complete synopsis of the waterlilies has hitherto been put before the English-speaking world,' and indeed it appears that it is more than eighty years since the last complete treatment in any language, i. e., De Candolle's in the 'Prodromus' (1824). The present work is the result of studies undertaken by the author in the botanical garden and laboratories of the University of Pennsylvania, supplemented by living and preserved specimens and material from many sources, including that in the herbaria in Kew, British Museum, Linnean Society, Berlin, Munich, etc.

It would be pleasant to summarize, or quote from the historical chapter in which many interesting facts are brought together in very readable form. Likewise there is much of interest and importance in the chapter on structure, which includes gross and minute anatomy, and in the next chapter on the physiology of the plants (including a discussion of the cause of the opening and closing of the flowers), but there is no space here for this. The reader is recommended to peruse the interesting chapters for himself.

The chapter on taxonomy is the one of most general interest to the ordinary reader. The author prefers the name *Nymphaea* to *Castalia* for the genus, reserving the latter for one of the subgenera. The species are arranged under two principal groups, viz., (I.) *Nymphaeae Aprocarpiae* (with carpels free from one another at the sides) and (II.) *Nymphaeae Syncarpiae* (with carpels completely fused with one another at the sides). Two subgenera are recognized in the first group, *Anecphyra*, with but one species, *N. gigantea* (Australian), and *Brachyceras*, with twelve species, *N. elegans* (Texas and Mexico), *N. ampla* (tropical and subtropical America), *N. flavo-virens* (probably Mexican), *N. stellata* (southeast Asia), *N. coerulea* (Africa), *N. micrantha* (West Africa), *N. heudelotii* (Africa), *N. ovalifolia* (East Africa), *N. calliantha* (Africa), *N. capensis* (South Africa), *N. sulfurea* (Africa), and *N. stahlmannii* (Africa). In the second group the subgenus *Castalia* in-

²"Tyro fit classes: magister fit species."

cludes seven species, *N. mexicana* (Florida, Texas, Mexico), *N. tetragona* (eastern Europe, Asia, North America to Australia), *N. fennica* (Finland), *N. candida* (northern Europe and Asia), *N. alba* (Europe and North Africa), *N. odorata* (eastern United States), and *N. tuberosa* (central United States); the subgenus *Lotos*, four species, *N. lotus* (Egypt), *N. zenkeri* (Africa), *N. pubescens* (East Indies), and *N. rubra* (East Indies); the subgenus *Hydrocallis*, ten species, *N. amazonum* (tropical America), *N. rudgeana* (tropical America), *N. blanda* (Guatemala), *N. lasiophylla* (Brazil), *N. gardneriana* (Brazil), *N. jamesoniana* (western South America and Porto Rico), *N. stenaspidota* (Brazil), *N. tenerinerva* (Brazil), *N. oxypetala* (Equador) and *N. gibertii* (Paraguay). It is noteworthy in this day when almost every monographer finds a lot of new species in his material, as a matter of course, that Doctor Conard describes but one new species, viz., *N. ovalifolia*, and a few new varieties. A second new species, *N. zenkeri*, by Professor Gilg, of Berlin, is here printed for the first time, although the name has been used for some time in European herbaria.

The closing chapter, mostly devoted to cultural directions, can scarcely be read without making one want to undertake the growth of some of these interesting plants. Beginning with such suggestions as 'the care of them is very simple; the pond or tank may be only a large bucket or a half barrel,' Doctor Conard proceeds to more and more elaborate suggestions, some of which can not fail to tempt his readers to make a beginning in their cultivation.

The author is to be congratulated upon having made such a notable contribution to botanical science.

CHARLES E. BESSEY.

THE UNIVERSITY OF NEBRASKA.

American Insects. By VERNON L. KELLOGG, Professor of Entomology and Lecturer on Bionomics in the Leland Stanford Jr. University. New York, Henry Holt & Co. 1905. Pp. 674.

In recent years a good many text-books or general works on the insects of America have

been published. Several of these have been limited to special fields, such as 'The Butterfly Book' and 'The Moth Book,' by Dr. Holland, and 'The Insect Book,' by Dr. Howard, the latter a companion book to Dr. Holland's volumes, covering the other orders of insects excepting the Coleoptera. Several text-books have, however, included the whole subject, among which may be mentioned Comstock's 'Manual for the Study of Insects,' Packard's 'Text-book of Entomology,' and volumes relating to insects more particularly in economic relations, such as Smith's 'Economic Entomology,' and Sanderson's 'Insects Affecting Staple Crops.' The best foreign work in English covering the general subject is Dr. Sharp's two volumes on insects in the Cambridge Natural History series, which remains the best work of its kind so far produced. Dr. Sharp's work, however, applies to the insects of the world. The volume prepared by Professor Kellogg, as indicated in the title, is limited practically to American insects, and is somewhat broader in scope than any of the American text-books so far published. The insect field in all its relations is so vast that it becomes a very difficult problem to include it even in a general way in a single volume, but Professor Kellogg has accomplished this very satisfactorily, on the whole.

As indicated in his preface:

This book is written in the endeavor to foster an interest in insect biology on the part of students of natural history, of nature observers and of general readers; it provides in a single volume a general systematic account of all the principal groups of insects as they occur in America, together with special accounts of the structure, physiology, development and metamorphoses, and of certain particularly interesting and important ecological relations of insects with the world around them. Systematic entomology, economic entomology, and what many be called the bionomics of insects are the special subjects of the matter and illustration of the book.

The structure and physiology of insects is gone into in considerable detail in the opening chapter. Metamorphosis and systematic classification of insects are rather briefly considered. The different orders and families of insects are then taken up seriatim, from the

lowest to the highest, and the structural characteristics, habits and transformations are discussed in some detail for the more important representatives of each family. The work includes also supplementary chapters on the relation of insects to flowers and the fertilization of plants, color and pattern and their uses, including also a discussion of protective resemblance, warning colors, mimicry, etc., and a chapter on the relation of insects to disease, discussing in some detail the relation of mosquitoes to malaria, yellow fever and filariasis. An appendix covers the general subject of collecting and rearing insects. The scope of the volume, therefore, is seen to be a very broad one. In some respects it reminds one of Dr. Sharp's excellent work, but falls short of the English publication in the character of the illustrations and in the general dignity of style. Professor Kellogg's work is designated apparently to arouse popular interest in the subject, and is somewhat uneven in style, varying from popular statement with an occasional indulgence in the rhapsody of the nature lover, to very technical and scientific matter.

The illustrations are very copious, including some 812 text figures and 13 plates, the latter mostly color-process reproductions from photographs. There are also many purely decorative figures. The text illustrations serve their purpose very well in supplementing the descriptive matter, but are of very unequal quality. Many of them are original, the work of Miss Mary Wellman; but many others are reproductions from standard European and other works and from the publications of various experiment station and other entomologists of this country. Very often old figures have been thus copied where much more accurate and better ones could have been substituted. Much of this reproduction and copying has evidently been done by means of photo-processes, and the result is rather unfortunate, especially in the case of the smaller figures, which are often mere blotches of black or at least have lost much of the structural detail which they originally possessed. The colored plates are most of them very good, and will enable the ready

recognition of the insects portrayed. The excuse is doubtless a valid one that, in a work as numerously illustrated as is this, the question of expense renders impracticable the careful preparation of all the illustrations.

Synoptical tables or keys to the different orders and families of insects are given throughout the book which will enable the student, with the aid of the illustrations, to form at least a rough classification of his collections.

An examination of the subject matter of the different chapters shows considerable care in getting the main facts and putting the information into semipopular language which may be readily understood by the student. While necessarily very largely a compilation, personal studies of the author in various special subjects greatly enrich the volume and give it freshness and originality. A great deal of interesting matter is thus contained in the volume, and the information given is reliable and correct as a whole. One notes, however, occasional errors of statement, evidently resulting from haste in the preparation of the work or careless compilation from original sources. For example, in the discussion of the fig insect, the *Blastophaga* is stated to have been imported directly from Asia Minor to California, when, in point of fact, the successful importations were from Algeria. In the discussion of luminosity of insects the matter is given a final status which is far from warranted by present knowledge of this interesting phenomenon. In the nomenclature the author has not followed the latest information, but in this particular he is perhaps justified, owing to the uncertain status of insect nomenclature and the frequent changes which are taking place, especially in the names of different genera. Some of the names employed can not, however, be excused on these grounds, and perpetuate old errors which have long been corrected in modern literature. The volume has no list of illustrations, but has a very full and useful index. The minor defects noted detract little from its real value, and Professor Kellogg's volume will be welcomed as one of the best general text-books on the subject covered. C. L. MARLATT.

The Educative Process. By WILLIAM CHANDLER BAGLEY. New York, The Macmillan Co. Pp. xix + 358.

As an attempt to organize the theory and practise of education in accordance with modern scientific thought and the results of psychological and genetic investigations, this book is well worthy of a review in SCIENCE.

In the view here presented, man is distinguished from other animals not only by his greater capacity to profit by his own experience, but especially by his ability to profit by the experiences of others transmitted to him through social habits and language. Education is the process by means of which the individual acquires experiences that will function in rendering more efficient his future action. Formal education includes the modifying influences, the control of which is consciously assumed either by the individual himself or by some educative agency, such as the home, church or school. The school is most important from the scientific point of view because its influence can be systematized and directed and the results determined.

Many of the principles of education are the same whatever the aim. The true aim of education may best be described as social efficiency. To be socially efficient a man must (1) pull his own weight, (2) interfere as little as possible with the effort of others, (3) consistently and persistently further progress.

Apperception is the reading of meaning into sense impressions and its chief law is 'The unifying of sense impressions into concrete experiences is accomplished through the adjustments to which the sensations themselves give rise.' The instincts of self preservation and of race preservation are the bases for the lower order of apperceptive systems, while those of the higher order are determined largely by acquired experiences.

Active attention and work must take the place of passive attention and play. The great work of the school is to produce this result and thus cause the instinctive and the near to be subordinated to the intellectual and remote. Hence education is largely a battle against nature. It should not, however, merely require certain activities, but it should de-

velop needs that will demand the acquisition of experiences that will be beneficial in mature life.

Experiences take the form of unconscious habits or of conscious judgments; the first should be unchangeable, the second adaptable. The judgments may be either practical or conceptional. A concept is an apperceptive system made explicit. There is danger of too much dealing with symbols before concepts are developed by experience. Ready-made instead of reasoned judgments are used a great deal. Organization is the important thing in conceptional judgments.

The stages of child development are a transition stage from six to eight, a formative stage from eight to twelve and the adolescent stage from twelve to eighteen.

Formal discipline in the sense of the generalization of a habit is not possible, but ideals may be carried over from one field of effort to another. The chief purpose of education is to develop high ideals. An ideal must be emotional as well as intellectual, and it is high as it is abstract, social, remote. Values of studies are classed as utilitarian, conventional, preparatory, theoretical, sentimental.

In the actual work of teaching, instincts need not development, but utilization, transformation or elimination. Not only should children be given models, but they should be led to admire them. Imitation starts processes and habits are formed by trial and error. Abstract teaching should lead to abstract judgments, not to more concrete.

Judgments may be given children ready made (the indirect method) or the child may be placed under conditions that will impel him to form them himself (the direct method). The indirect method is the principal one in the elementary schools.

The media of intellectual transmission are oral discussion, books and graphic representation, and of emotional transmission, literature, pictorial and plastic art and music and oratory.

Inductive development lessons are valuable though they have limitations, but deductive development lessons are equally important while the study lesson, the recitation lesson,

the drill, the review and the examination lessons have each an important place.

Such, with an additional chapter on the 'Hygiene of Instruction,' are the main thoughts of the book very briefly summarized. It is evident that this is a broad systematic treatise far in advance of the traditional pedagogical work on theory and practise. It gives promise of a body of knowledge founded on the established principles of biology, sociology, psychology, child study and educational practise, that may soon be designated as a science of education without any apologies.

The biological and psychological aspects of education are most emphasized, and the treatment of education reduced to its lowest terms in the earlier chapters is admirable. Hobhouse on genetic psychology and Hall on child study are his favorite authorities, while on general psychology most of the leading psychologists of the day are referred to and quoted. His facts and principles are, therefore, generally reliable.

A very noticeable, though minor, error in his psychology, is shown in his statement that marginal vision is now of no use to man. The most fundamental defect in his early formulation of the foundations of the science of education is his failure to recognize the significance of other instincts than those concerned directly in self and race preservation. Man with his adaptive instinct of play, curiosity and imitation, and his regulative instincts of morality and religion, to say nothing of his social, collective, constructive, dramatic, expressive and other instincts so much stronger than in animals, is naturally a learning, language forming, socially organizing animal. The right utilization of these instincts is the keynote of modern education instead of the old idea of the teacher as battling against nature which is expressly endorsed in chapter VI. by this author. Later he recognizes some of these instincts, but he nowhere gives them their true place as powerful springs of action by the proper utilization of which much of the war against nature in education may be charged to the wise direction and regulation of natural activities of children.

In another respect the book is very unsatis-

factory to the writer and certainly not in harmony with present educational movements. This is in his emphasis upon the indirect method of giving readymade judgments and of teaching by means of symbols. He admits the value of learning by experience and the artificial character of most school education, but yields so completely to the old school idea that in discussing media of instruction he omits to mention objects themselves (though in another place he discusses the use of objects, museums and excursions). At the present time when the best teachers are making great advances in rendering education less artificial through the more extensive and efficient use of objects and manual activities of all kinds, it is very disappointing to have a work that is so up to date in most respects fail not only in contributing something to this desirable advance, but to even pass it by as of little significance.

In one other respect the author's position is reactionary and in the light of present day thought and investigation untenable. This is shown in his endorsement of the absurd idea that the study of grammar rather than practise in seeing, hearing and using correct language is the proper method of learning to use good language forms. In this connection he holds that generally the conscious focusing of the mind upon each step is necessary to the rapid, efficient formation of habits. This is true in a large measure in adult, analytic and synthetic intellectual activities but not at all true of the lower order of intellectual and manual habits, especially of children, in whom the stages of analysis and synthesis are undifferentiated. In such cases the attempt to analyze and focalize on each step retards seriously the formation of habits. If children had to learn to walk, talk, control their bodies, etc., by the method of consciously focusing upon each step in those processes, many more years than are now required would be necessary to a much less perfect establishment of those habits. Even with older children, if the game of ball had to be learned by the method of focusing on each phase of the process, success in catching, batting, etc., would probably take much more of the boys'

time than it now does by the natural method. The most pernicious and untenable application of this idea appears when he claims that a child's attention should be focused upon the exact mistake he has made in previous repetitions.

In spite of these and some other less important mistakes and misplacements of emphasis, the book is a fresh, stimulating and generally correct organization of the principles of education.

WILBUR S. JACKMAN.

The Study of Chemical Composition. By IDA FREUND, Staff Lecturer and Associate of Newnham College. Cambridge, University Press. 1904. 8vo. Pp. xvi + 650.

This book presents an account of the method and historical development of the study of chemical composition. The initial discoveries forming the basis of the modern views of the composition of bodies are described, and the methods by means of which further experimental facts bearing upon the subject were obtained are clearly set forth. The historical development of the important laws is traced by showing how these grew from the study of certain classes of phenomena. In the course of this presentation many well-chosen quotations from classical original articles, including actual experimental data obtained, are given in sufficient detail to enable the reader to form an idea as to the degree of accuracy attained in the experiments which are of special consequence. Though the historical method of treatment has been adopted, no attempt has been made to secure such completeness or proportion as to deserve the name of history. The aim has been to describe only the most vital discoveries, and to do this thoroughly, rather than to dwell upon a greater number of facts.

A carefully written introduction of thirty pages devoted to a discussion of the method of inductive sciences prefaces the nineteen chapters in which the subject matter is treated. The first eight chapters deal with theories of combustion and the composition of bodies by weight. Here the work of Lavoisier, Dalton, Richter, Berthollet, Proust, Stas, Morley and

others is described. Chapter nine presents the views concerning the constitution of matter held prior to 1800, and the following chapter deals with Dalton's atomic theory. Chapters eleven to thirteen relate to the combination of gases by volume, the work of Avogadro and Cannizzaro, and the molecular hypothesis. After detailing the discovery of Dulong and Petit in chapter fourteen, the subjects of isomorphism, periodic law, valency and isomerism are treated in the chapters following, and the book is fittingly closed with a final chapter setting forth the modern views concerning the ultimate constitution of matter and the genesis of the elements.

Throughout the book, facts and theories have been sharply and clearly separated from each other, a matter of vital importance in a treatise of this nature. The treatment is concise, clear and conservative, yet none the less interesting. The book can be heartily recommended to students of physical science and others desiring a reasonably condensed presentation of the existing views of chemical composition. Like the other volumes of the Cambridge Physical Series, the book is well printed.

LOUIS KAHLENBERG.

SCIENTIFIC JOURNALS AND ARTICLES.

The American Naturalist, with the exception of the *American Journal of Science*, the oldest of the American scientific periodicals, announces a change in its editorial management. Dr. William McMichael Woodworth, who has so acceptably filled the position of editor-in-chief since 1898, retires and his place is taken by Dr. Glover M. Allen, the secretary of the Boston Society of Natural History. All correspondence intended for the editorial department should be directed to *The American Naturalist*, Cambridge, Mass.

THE October issue of the *Journal of Nervous and Mental Disease* opens with a report by Dr. Frank R. Fry of a case of cerebral tumor which presented some puzzling symptoms which led to the belief that the tumor was located in the left cerebellum, whereas the autopsy discovered it occupying the greater part of the site of the left inferior

frontal convolution. A paper by Dr. John Punton follows, treating of mysophobia, with a report of a case, and emphasizing the close relation which exists between the so-called neurasthenias and insanity. Dr. Theodore A. Hoch's paper on acute anterior poliomyelitis, begun in the previous number, is concluded, with an exhaustive bibliography, and Dr. William W. Graves contributes a short paper on anesthesia associated with hyperalgesia sharply confined to the areola-nipple area of both breasts, which his experience leads him to consider as a pathognomic and practically constant stigma in hysteria.

WE learn from the *British Medical Journal* that the publication of a quarterly periodical, to be called the *Journal of Tropical Veterinary Science*, has been undertaken by Messrs. H. T. Pease, principal of Lahore Veterinary College; F. S. H. Baldry, professor of sanitary science, Punjab Veterinary College, and R. E. Montgomery, assistant imperial bacteriologist, Imperial Bacteriological Laboratory, Muktesar, U. P. Each number will, as far as possible, consist of original articles of scientific interest, with reviews and extracts from current literature. Nothing of a personal or political nature will appear in the journal. Amongst the subjects to be dealt with in the forthcoming numbers, for which arrangements have already been made, will be a series of articles on the anatomy, physiology, and pathological conditions of the camel and the elephant; the intestinal and other parasites of animals; the biting flies and the ticks of India, together with their importance in the transmission of disease. The first number will appear on January 1, 1906. The publishers are Messrs. Thacker, Spink and Co., Calcutta.

DISCUSSION AND CORRESPONDENCE.

CYANIDE OF POTASSIUM.

TO THE EDITOR OF SCIENCE: Recently when at Minas Prietas, Sonora, at the cyanide plant of Charles Butters, Limited, I observed in one of the settling tanks which was nearly full of pulverized ore, known metallurgically as 'slime,' that the surface of this material, which was saturated with and covered by a

solution of cyanide of potassium, was pitted by holes and marked by trails, which I assumed to belong to some small invertebrate. That they were of organic origin seemed too obvious to be worthy of question.

There was no opportunity for me to wait until the solution was drawn down sufficiently to permit of a careful examination of the surface of the pulverized material, so it remains for some future observer to determine the identity of the form which produced the markings.

The observation is communicated to you in the hope that it may invoke a communication of similar observations on the part of others. What seemed remarkable to the writer was that any form of animal life could exist in a solution of cyanide of potassium.

F. J. H. MERRILL.

SPECIAL ARTICLES.

THE PARACHUTE EFFECT OF THISTLE-DOWN.

THE importance of the down of the Canada thistle (*Carduus arvensis*) for seed distribution is a matter of common knowledge, but it may not be quite so well known just how this is accomplished from a mechanical point of view.

When the head of the Canada thistle is mature and the day dry (moisture closes up the head even though mature), the scales of the involucre spread and expose the fluffy mass to the air. At this time the achenes may be detached from the receptacle by the slightest force, permitting them to float away attached to the down. This closing of the head is brought about by the unequal turgescence of the cells in the bracts of the involucre.

The down which grows on the receptacle—not on the achenes—serves the function of helping to keep water from entering the head, thus permitting the achenes to become thoroughly dry, though the weather may be damp at the time. Dampness tends to hold the achenes fast to the receptacle, and this tends, in some measure, to defeat the purpose of the down, because it may become detached from the achene and float away without its precious burden. Both the calyx-down and the recep-

tacle-down are of such a nature that water will not adhere to them. This is because the surface has a stronger attraction for air than for water, owing to the fact that the surface is coated with a substance of an oily nature. Alcohol removes this substance.

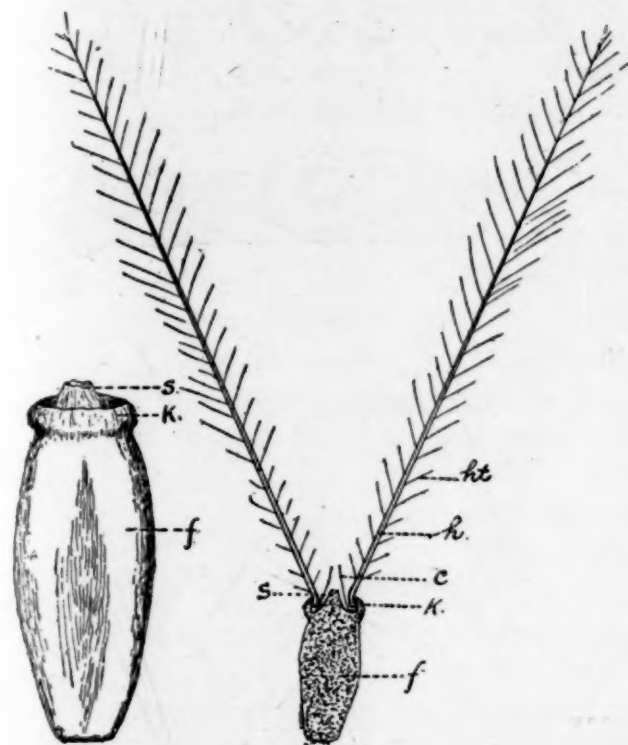


FIG. 1. *f*, the fruit (achene); *k*, collar round the summit of the achene, inside the edge of which the pappus hairs are supported, at the base for a distance of about .25 mm., forming a ring; *h*, the hair; *ht*, the hairlet; *c*, the base of the withered corolla; *s*, remains of the style broken away. (The style and corolla usually persist until the achene breaks from the pappus.) The diagram to the right is an imaginary vertical section. The drawing to the left is a view of an achene after the down has been detached. The hairs when dry are at an angle of about 45° to the vertical. The hairlets are at an angle of about 45° to the axis of the hair. Hence the hairlets make an angle of about 90° to each other, so that at whatever angle they be placed, the resultant effect can not be less than that of 45°. It will be noticed that the collar *k*, being slightly smaller at the extreme edge, clamps round the base of the ring of hairs. This is the more effective because the ring of pappus is slightly larger at its lower edge, making the collar act like a wedge. This is indicated in the diagram to the right.

From the nature and the position of the receptacle-down, it may once have served the function of moving the whole head by the aid of the wind; so that the suggestion is here offered that the achene-down is a later development from the point of view of evolution.

When the down, with its attached achene, is exposed to dry air for a few days, the contracting end of the achene causes it to rupture from the collar of the calyx-down, and thus a separation takes place eventually. This, of course, is an advantage, because the seed may thus reach a suitable place in the soil for germination. If the pappus remained attached, the chances for germination would be greatly diminished, because the down would then be but a hindrance by holding the achene above the soil. In many cases, therefore, the thistle-down seen floating in the air has no achene attached; and this separation would likely take place while floating in the air, because of the favorable conditions there for drying out.

A minute examination was made of several heads of thistle-down with a view to ascertain to what extent the down was adapted to the air conditions. In the heads there are from 95 to 120 achenes; or an average of about 108 per head; and there is an average of 80 hairs to one achene-cluster, and 110 hairlets on each hair. These hairlets are .005 mm. in diameter and 2 mm. long (approximately). The surface area of each hairlet would be $\pi \times .005 \times 2$; and of all the hairlets in each head: $\pi \times .005 \times 2 \times 80 \times 108$ sq. mm. The hairs being each .06 mm. in diameter, and 23 mm. long, the surface area for the whole head would be:

$$\pi \times .06 \times 23 \times 80 \times 108.$$

The cells composing the pappus are filled with air when the achenes are mature, and this adds to the buoyancy, but the inside surface is not here computed because it has nothing to do directly with the surface attraction of the pappus for the air of the atmosphere.

The total external surface area, therefore, would be:

$$\begin{aligned} &\pi \times .005 \times 2 \times 110 \times 80 \times 108 + \\ &\quad \pi \times .06 \times 23 \times 80 \times 108 \\ &= 67,342.6 \text{ square mm.} \\ &= 673.426 \text{ square cm.} \end{aligned}$$

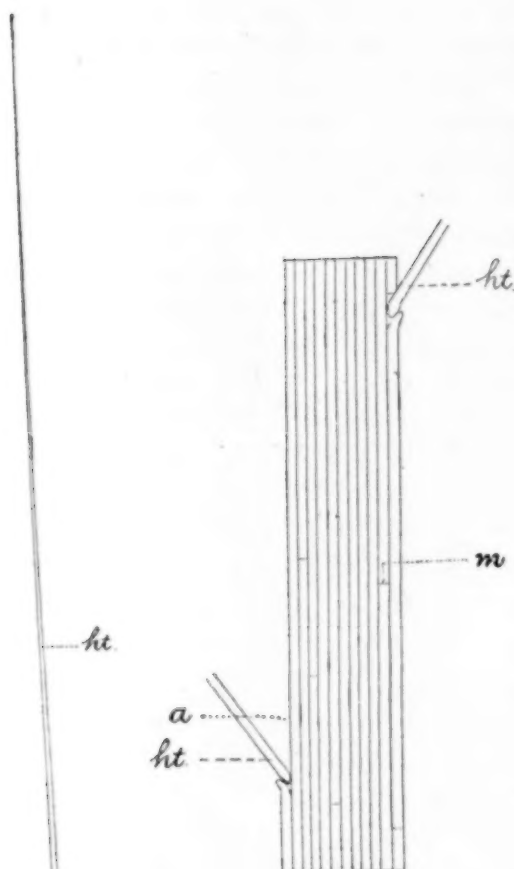


FIG. 2. The diagram to the left shows a hairlet, single cell, cavity filled with air. The other diagram is an optical longitudinal section through the diameter of a hair, showing the long, narrow, thin-walled cells. These are filled with air. *m*, cross wall; *ht*, hairlet; *a*, narrowing due to the extended cell *ht*. This illustrates the chief means of tapering of the hair, it being smaller at this point by the size of the hairlet.

Now, if this down-substance be considered as a flat lamina, it would have an area of one half of 673.426 sq. cm., because the lamina has two sides; and, as the lamina would be so exceedingly thin, the other surfaces may be neglected. Now, if *t* represent the thickness in centimeters, *a* the area in sq. cm., and *s* the specific gravity of cellulose,

$$\text{then } ats = \text{weight in grams,}$$

but, by actual experiment, the weight of all

the 'downs (excluding achenes) in a head' is .0561 grams,

$$\begin{aligned} \text{therefore } ats &= .0561 \\ &= \frac{.0561}{as} \\ &= \frac{.0561}{336\,713 \times 1.13^1} \\ &= .0000375 \end{aligned}$$

the thickness of the lamina in cm. It would, therefore, require over 26,000 of such laminae to produce a thickness of one cm.

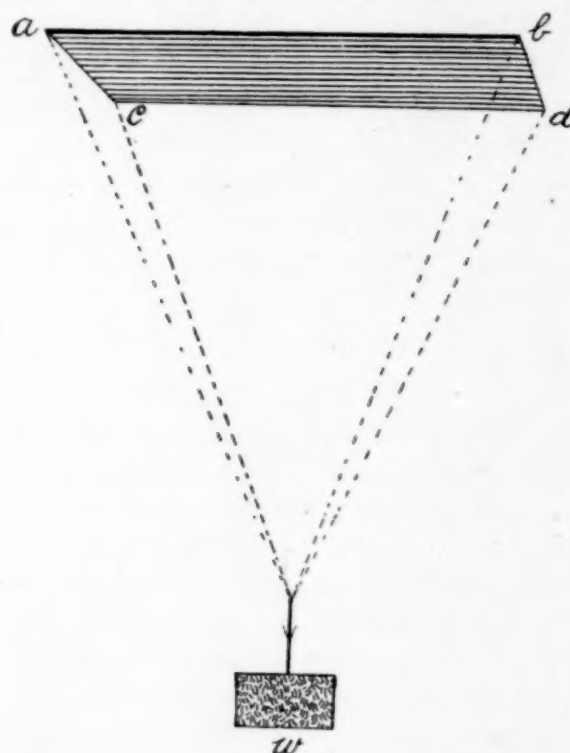


FIG. 3. Illustrates the parachute action of the lamina *abdc* when it is horizontal and, therefore, capable of producing its greatest effort. In the calculation, $w = 150$ lbs.

In the Standard Dictionary there are about 2,300 pages, having a total thickness of 11 cm., something over 200 pages to the centimeter. Therefore, to express in a striking manner, it may be said that it would take about 130 of such laminae to make the thickness of one leaf of the paper just mentioned.

The weight of the achenes themselves—excluding the down—in a head, are approximately .108 gram; so that, for each gram weight of achenes, there is a surface area of 6,235.42 square centimeters.

¹The specific gravity of cellulose in Swedish filter paper is 1.13 very approximately.

The adaption of thistle-down to floating in the air is seen at once to be quite remarkable.

The down acts as a parachute to carry the seed, and a calculation will set forth how great this force may be. It will be considered that the lamina referred to is placed horizontally and the achene attached. The rate at which the achene (with the down attached) will fall in still air is as explained in the solution given below:

In the formula $P = .004V^2S$, P stands for the pressure in pounds per square foot, V the velocity in miles per hour, and S the number of square feet.

The downs and the achenes in a head weigh

$$.108 + .0561 = .1641 \text{ gram,}$$

and the surface area of one side of the lamina is 326.713 square centimeters; but one gram = .0022046 pound, and one sq. cm. = .155 sq. in., therefore,

$$.0022046 \times .1641 = .000361 \times \frac{326.713 \times 155}{144}$$

$$\therefore V = .35 \text{ miles per hr. (approx.)}$$

From this it may be seen that a thistle-down starting from an elevation of 20 feet, would take 20/1848 hours to fall; and if we suppose the wind to be blowing at 20 miles per hour, the achene would be carried a distance of .21 mile, i. e., about one fifth of a mile. In this calculation, all cross currents and changes of air are neglected.

In this parachute calculation, the lamina is supposed to be horizontal. This condition would necessarily give the maximum of the parachute effect. Now, if this be represented by E , the minimum effort could not be less than $1/\sqrt{2} E$, because of the configuration of the parts of the thistle-down.

Another illustration might possibly bring out more prominently the parachute effect: If a weight of 150 pounds be attached to the down in such a way that they will act with the maximum effect; and it be required to ascertain how many would be required to 'parachute' that weight so that it would fall

² Kent's 'Mechanical Engineering,' pocket edition, p. 492. This is the value given by Smeaton, 1759, but others have given it as low as $P = .0029V^2S$.

at the rate of five miles per hour, the equation would be

$$150 = .004 \times 5 \times 5 \times S,$$

therefore,

$$S = 1,500 \text{ square feet;}$$

but the down-lamina is, for a whole head of 108 achenes, 326.713 sq. cm., or .3624 sq. ft., therefore it would require

$$\frac{1,500 \times 108}{.3624} = 447,019 \text{ downs.}$$

In all these calculations, neither the viscosity of the air nor its capillary (surface) attraction is taken into account, though the

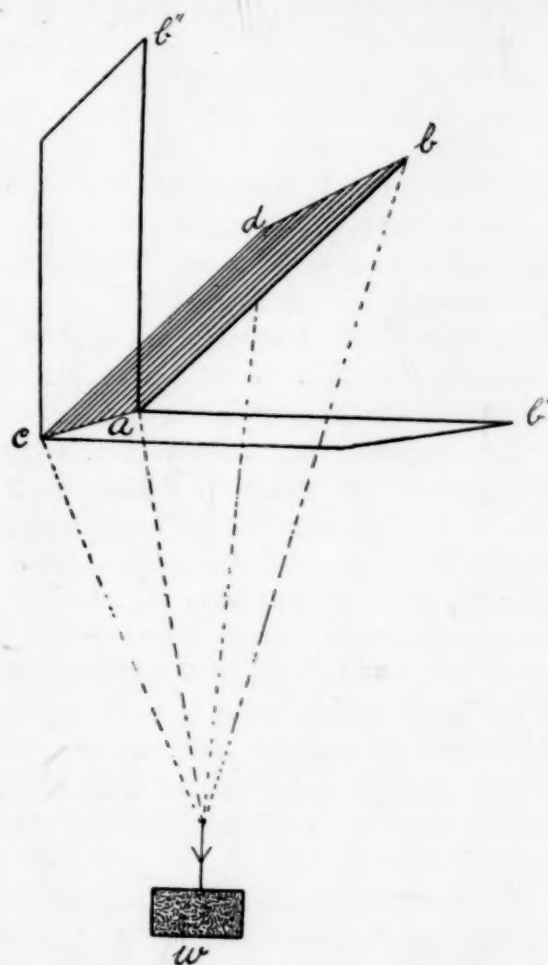


FIG. 4. The plane $abdc$ is at an angle of 45° . The horizontal cross-section of the mass of air displaced in the descent of the plane, in this position, would be the area of $abdc$ divided by the square root of 2. From the configuration of the parts of the down, this would give the minimum effect. (See Fig. 1.)

latter is very considerable, as may be seen from the fact that small (microscopic) particles of sand, iron and the like, float, and

fall very slowly in the air. Theoretically, a small spherical body should fall at the same rate as a large spherical body of the same composition; but it does not, and this may easily be demonstrated by throwing a shovelful of coal composed of pellets of various sizes—some as fine as dust—into the air at a height of even six or eight feet. The very finest dust floats for some time in the air, and the largest pellets reach the ground first. It is indeed due to this surface attraction that small bodies like pollen grains, fungus spores and the like, are capable of being transported through the air over such great distances.

J. B. DANDENO.

AGRICULTURAL COLLEGE, MICHIGAN,
April 3, 1905.

THE WEIGHT OF THE BRONTOSAURUS.

At the request of Professor H. F. Osborn the writer undertook to make an estimate of the probable weight in the flesh of a *Brontosaurus excelsus*. The mounted skeleton in the American Museum is 66 feet 7 inches long, and from this a very carefully studied model or restoration was made by Mr. Charles R. Knight, who also made use of Dr. W. D. Matthew's studies upon the probable size and arrangement of the muscles in this animal. The skeleton was mounted after the prolonged study and discussion of a number of specialists; its contours are strikingly lifelike, and Mr. Knight's long training well qualified him to infer the external contours of an animal from its internal framework. Hence the model should correspond fairly well with the animal itself.

From the model, a number of plaster casts were made, and one of these was used in the following determination. The model was constructed as nearly as possible to the exact scale of one sixteenth natural size, hence the cubic contents of the model multiplied by the cube of 16 (4096) should indicate the probable volume of water which would be displaced by the animal in the flesh. One of the casts was cut into six pieces of convenient size, which were then made water-tight by a double coating of shellac. Professor William Hallock very kindly consented to determine accurately

the cubic contents of these pieces in one of the physical laboratories at Columbia University.

The weight of the cast in air minus its weight in water would equal the weight of an equal volume of water. This differential weight was determined in grams. As a gram is the weight of a cubic centimeter of water the weight of the water displaced gave directly the cubic contents of the model. Professor Hallock found the weight of the water displaced to be 7,595 grams (about .27 cubic feet), or say 7.6 kilograms. Hence the animal itself would displace $7,595 \times (16)^3 = 31,129,600$ c.c. or 31.13 metric tons. Converting this into tons, we have $31.13 \times 2,200 \div 2,000 = 32.24$, or say $34\frac{1}{4}$ tons, as the estimated weight of the water displaced by the animal. But as the animal was probably slightly heavier than the water displaced, in order to enable it to walk on the bottom along the shore of lakes and rivers, we may add about ten per cent. to $34\frac{1}{4}$ tons, securing as a final estimate 38 tons.

This result accords very well with Mr. F. A. Lucas's careful estimate of the weight of a 75-foot sulphur bottom whale, an animal of much greater bulk than the *Brontosaurus*. This weighed about 63 tons, and in conversation with the writer Mr. Lucas expressed the opinion that the *Brontosaurus* did not weigh 'much more than half as much.' This opinion seems justified by the estimate given above.

W. K. GREGORY.

AMERICAN MUSEUM OF NATURAL HISTORY,
NEW YORK,
September 30, 1905.

QUOTATIONS.

COLLEGE ADMINISTRATION.

Of the several conferences of the installation week at Champaign-Urbana, the one announced as a conference of trustees to consider methods of administration builded larger and possibly better than it knew. It included not alone the problems of the conduct of the business machinery of these great corporations, but raised the fundamental issues in regard to *raison d'être* of boards and presidents, and administrative means and measures. And it raised the most pertinent query as to the

dangers inherent in the further development of the presidential office in its present temper. With unexpected corroboration of many men of many minds, the autocracy of the college president—to which President Pritchett has called timely attention—was deplored, not alone as undemocratic in principle and harsh in practise, but as tending to undermine the stability of the academic career, and as taking from it its proper dignity, honor and station. It is certainly notable that an occasion that was convened to glorify the president—though in some part only as the representative of his university—the dominant theme of discussion should take as its text the menace and evils of this office. The inquiry was most amicably and fairly conducted; no disturbing factor of personal criticism intruded itself. It was admitted that the needs of the past—closely associated with pioneering crudities and exacting conditions—demanded dictatorial powers, central responsibility, efficient and compromising direction. Yet it was questioned whether this type of government is at all promising for present and future situations. Our universities have been built up too largely at the sacrifice of the academic career; and with material success and the ambition to be big has come a neglect of quality and of the true ends for which universities are maintained. The faculty has paid all too heavily for the progress which it has, with unacknowledged sacrifice, made possible. The issue is thus nothing less than the rehabilitation of the academic career; the restoration of the faculty to a truly directive authority of the educational affairs of the university; the withdrawal of the president to the more modest office of the leading interpreter of faculty opinion, and the interpretation of the function of the board in a more cooperative, less managerial tone. That intense and hampering sense of accountability—which President Pritchett has likewise emphasized—robs the professorial career of its essential worth; and this accountability directly results from the autocratic government by presidents and boards, that imposes policy upon the faculty, and distributes with both a grudging and an unjust hand rewards for

facilitation of administrative measures. Naturally, when stated thus baldly the charge seems exaggerated and in many quarters wholly inappropriate; yet, as a tendency, it has real existence and unusual power to make or mar the academic career. Analogies from the business world have wrought havoc with educational standards, and, unless signs fail, this is to be one of the foremost of educational questions; and it may be that the formal raising of this query will come to be regarded as the memorable feature of the Illinois conferences.—*The Outlook*.

THE BIRD LIFE OF CENTRAL ILLINOIS.

THE Illinois State Laboratory of Natural History is making a qualitative and quantitative survey of the bird life of a typical grain and cattle farm of central Illinois, with the intention of continuing and extending statistical studies of this description until average results are arrived at, good for the various crops and regions of the state and for the different seasons of the year. This is taken up mainly as a study in ornithological ecology, but it will nevertheless have an economic value as helping to determine the real significance of birds in relation to agriculture.

The data are obtained by an expert field ornithologist who, with a single companion, crosses a four-hundred-acre farm in various directions and at intervals of about four days, the two observers traveling always fifty yards apart and noting the species and numbers of birds flushed on this strip between them. They carry each time a copy of a plot of that part of the farm covered by their trip, drawn to a scale and showing the distribution and areas of each of the crops. On this plot the position of each bird observed is noted, the series of diagrams thus giving a means of determining the average bird population per acre for each crop as well as for the entire area covered.

This work has been in progress since last June, during which time the birds of something over 1,100 acres have thus been accurately recognized and numbered for three summer months. The average was 2.5 birds per acre, omitting English sparrows, or 3.8

per acre if the sparrows are included. The total number of species observed was 38, and the number of birds identified was 4,257. Fifty-nine per cent. of the individuals seen were bronzed grackles, 13.3 per cent. were English sparrows, 12.5 per cent. were cowbirds, 2.5 per cent. were mourning-doves, and 2.3 per cent. were meadow-larks. Nearly 90 per cent. of all the birds on the farm thus belonged to these five species, and to them was due virtually all the impression which was being made by birds on the plant and insect life of this tract.

THE INTERNATIONAL CONGRESS OF AMERICANISTS.

WE have already called attention to the fact that the fifteenth International Congress of Americanists will be held at Quebec from September 10 to 16 of next year. The regulations adopted by the committee of organization are as follows:

Papers will be listed on receipt of title.

Papers will not be assigned a place on the preliminary daily program unless an abstract has been received, as required by the rules and regulations of the congress.

Papers to be read will be arranged according to subject-matter, in a number of divisions corresponding to those of the general program; and papers belonging to the same division will be presented, so far as feasible, on the same day.

Papers in each division will take precedence in the order of the receipt of abstracts.

Authors who intend to submit more than one paper to the congress are requested to designate the paper they desire to read first. The rest of their papers will be placed at the end of the preliminary program of the respective divisions.

In order to insure the prompt publication of the proceedings of the congress, the committee recommends to the congress to set the latest date for the receipt of completed manuscripts and of notes of discussions, October 1, 1906.

SCIENTIFIC NOTES AND NEWS.

BRIGADIER GENERAL A. W. GREELY, chief of the U. S. Signal Service, has been elected the first president of the Explorers' Club, an organization recently founded in New York City.

PROFESSOR EMIL FISCHER, of Berlin, has been elected an honorary member of the Society of German Chemists.

PROFESSOR ROBERT KOCH, who has been at Amaris in West Usambara and at Uganda to complete his researches on trypanosomes and sleeping sickness, expected to reach Berlin on October 23.

DR. FORREST SHREVE, Bruce fellow in the Johns Hopkins University, sailed for Jamaica on October 13, to spend a year in physiological and ecological work at the Cinchona station of the New York Botanical Garden.

DR. R. M. WENLEY, professor of philosophy in the University of Michigan, has leave of absence for the year, which he is spending in Scotland.

PROFESSOR A. B. STEVENS, who has been studying in Switzerland for two years, has returned to the University of Michigan and will continue his researches upon the composition of poison ivy.

MISS FANNY COOK GATES, who has been engaged in research work in the Cavendish laboratory since last April, has resumed her duties as head of the physics department in the Woman's College of Baltimore.

DR. G. R. HOLDEN and Dr. H. M. Little, respectively resident gynecologist and obstetrician of the Johns Hopkins Hospital, have resigned, and Dr. Stephen Rushmore and Dr. F. C. Goldsborough succeed them. Dr. Little will take charge of a department in the hospital connected with McGill University, Canada.

DR. J. C. R. LAFLAME, formerly rector of Laval University and president of the Royal Society of Canada, has been appointed by the International Waterways Commission as geological expert to make a report upon the recession of the Canadian side of Niagara Falls.

BARON K. TAKAKI, of Tokyo, has accepted an invitation to deliver the Cartwright lectures on surgery in Columbia University. Surgeon-General Takaki will sail for America towards the end of December.

AMONG the lectures to be given before the Royal Institution of London during the current session are the following: 'The Origin of the Elephant,' Professor E. Ray Lankester, F.R.S.; 'Submarines,' Sir W. H. White, K.C.B., F.R.S.; 'Geographical Botany interpreted by Direct Response to the Conditions of Life,' Rev. George Henslow; 'The Upper Nile,' Sir Charles Eliot, K.C.M.G.; 'Variation in Man and Woman,' Professor Karl Pearson, F.R.S.; 'Our Atmosphere and its Wonders,' Professor Vivian B. Lewes.

THE Traill-Taylor memorial lecture of the Royal Photographic Society of Great Britain was delivered at the New Gallery, Regent Street, London, on October 24 by Mr. Chapman Jones, F.I.C., F.C.S. The subject was 'Photography, the Servant of Science.'

At the meeting of the Institution of Civil Engineers on November 7, Sir Alexander R. Binnie, the president, will deliver an inaugural address, and the presentation will take place of the council's awards.

BEFORE the Pupil's Physical Society of Guy's Hospital, on October 12, Dr. William Osler, the regius professor of medicine of Oxford University, delivered an address upon 'Sir Thomas Browne,' who was born on October 19, 1605.

DR. SYLVESTER DWIGHT JUDD, formerly assistant biologist in the U. S. Department of Agriculture and professor of biology in Georgetown University, committed suicide on October 22, two weeks after his discharge from the insane asylum. Dr. Judd, who was thirty-four years of age, graduated from Harvard University in 1894. He had made valuable contributions to economic ornithology.

The annual meeting of the American Physiological Society will be held at the University of Michigan, Ann Arbor, December 27 and 28.

THE twenty-third annual congress of the American Ornithologists' Union will be held at the American Museum of Natural History, New York City, beginning on the evening of Monday, November 13. The evening session will be for the election of officers and members, and for the transaction of routine busi-

ness. Tuesday and the following days will be for the presentation and discussion of scientific papers, and will be open to the public.

THE tenth International Geological Congress will meet in the City of Mexico at the beginning of September, 1906. Extended excursions have already been arranged to precede and follow the congress.

At a joint meeting of the Royal Society and the Royal Astronomical Society, held on October 19 at Burlington House, the following reports were presented on the subject of the total eclipse of the sun on August 30: 'Preliminary Account of the Observations made at Sfax, Tunisia,' by Sir William Christie, the astronomer royal; 'Preliminary Report of the Observations made at Guelma, Algeria,' by Mr. H. F. Newall; 'Report of the Eclipse Expedition to Pineda de la Sierra, Spain,' by Mr. J. Evershed; and 'Expedition to Aswan,' by Professor H. H. Turner. A report was also presented by Professor H. L. Callendar, F.R.S.

FRANCE, following the example of England, Germany and other countries, has decided to create an Order of Merit. The new decoration is intended for Frenchmen who shall have distinguished themselves at home or abroad, but whose services would not entitle them to the Legion of Honor. There are to be three grades—chevalier, officer and commander—and the ribbon is to be dark blue. The new order is intended to take the place of the medals and decorations now conferred for special services.

By the will of the late Benjamin P. Davis, a civil engineer of New York City, \$250,000 is bequeathed for public purposes, including \$50,000 to the Metropolitan Museum of Art, \$50,000 to the Phillips Exeter Academy of New Hampshire and \$25,000 to the American Museum of Natural History.

THE Royal College of Surgeons has presented to the medical department of Cambridge University a number of portrait engravings of eminent physicians and surgeons of the seventeenth and eighteenth centuries.

THE valuable collection of succulent plants made during his travels abroad by the late

Rev. H. G. Torre, of Norton Curliu, Warwickshire, has been presented to the Royal Botanic Society. It comprises some 1,600 specimens of the most ornamental of the class, such as agaves, aloes, echeverias, crassulas and mesembryanthemums. The rockery in the large conservatory has been reconstructed for their accommodation and display.

UNIVERSITY AND EDUCATIONAL NEWS.

THE late George W. Catt, a civil engineer, has bequeathed his engineering books and half the residuary interest in his estate, which in all is estimated at \$110,000, to the Iowa State College of Agriculture and Mechanic Arts.

THE trustees of Smith College, at a meeting in Northampton on October 20, voted to use the money donated by Mr. John D. Rockefeller for the erection of an assembly hall and a dormitory. The college register shows the freshman class to be the largest in the history of the college, having 404 members, an increase of 46 over that of last year.

THE statement of the president of the University of Chicago for the quarter ending September 1 contains the following report of receipts and expenditures during the past eight years:

Fiscal Year.	Receipts.	Expenditures.
1897-8	\$ 706,973.63	\$ 678,399.75
1898-9	723,083.01	719,923.52
1899-0	740,954.93	747,186.62
1900-1	775,654.98	790,583.68
1901-2	977,828.33	944,348.26
1902-3	982,609.94	1,020,224.92
1903-4	939,073.72	1,032,533.39
1904-5	1,003,750.33	1,003,726.47
Total.	\$6,849,928.87	\$6,936,926.61
Net deficit.	\$ 86,997.74	

EMMANUEL COLLEGE, Cambridge, announces that a studentship of the annual value of £150 will be offered for encouragement in research in any branch of study recognized by the university, open to graduates of the university whose age does not exceed 28 on January 1, 1906. It will be tenable in the first instance for one year, but the student may be reelected for a second period of one year, the studentship not to be tenable with a fellowship or any similar studentship.

ACCORDING to the New York *Evening Post* the registration of the University of Pennsylvania is as follows:

	1904-5.	1905-6.
College Department	946	1,089
Wharton School	226	271
Teachers' Course	181	208
Evening School	95	298
Summer School	131	214
Philosophy	213	287
Law	303	315
Veterinary	79	100
Dental	359	322
Medical	546	580
Spring Medical.....	17	19
Total	3,096	3,703

THE first Servian University was opened on October 15 by the king in presence of the crown prince, the members of the ministry, invited guests and Servian delegates.

MR. ELLSWORTH GAGE LANCASTER has been installed as president of Olivet (Michigan) College.

THE chair of philosophy in Miami University, which was from 1888 to 1905 in charge of Dr. R. B. C. Johnson, now at Princeton, has been filled by the appointment of Elmer E. Powell, Ph.D. (Bonn).

DR. ARTHUR GRAHAM HALL, formerly instructor in mathematics at the University of Michigan and associate professor of mathematics at the University of Illinois, has accepted the professorship of mathematics in Miami University resigned by Edward P. Thompson.

PROFESSOR WALTER M. BOEHM will have charge of the work in physics at Cornell College, Mount Vernon, Ia., during the coming year, Dr. A. Collin having been granted a leave of absence. Mr. Boehm is a graduate of the State University of Iowa, where for three years he served as assistant in physics.

DR. OSCAR VELEN, of the University of Chicago, has been appointed preceptor in mathematics in Princeton University.

DR. WILLIAM FOSTER, JR., has been advanced to an assistant professorship of chemistry in Princeton University.